Wave-Particle Paradox and Evans Photomagneton

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1.0 INTRODUCTION

Physical objects from quarks to planets have wavelike attributes. Quantum theory offers a mathematical model for the observed wave-particle dualism. This article gives a physical model for the wave-particle duality nature of photons, electrons, protons, neutrons, atoms and molecules. It explains the non-thermal, intrinsic electromagnetic inertia, simple harmonic motion, resonance Compton frequency, oscillation nature of quantum particles and gives a physical interpretation of the string theory, wave mechanics, two-slit interference and the Faraday effect.

A physical model of the nature of the electron is suggested. Also given is a possible explanation for the magnetic field of a black hole, neutron star and the Sun.

2.0 QUANTUM PARTICLES

A quantum particle is never at rest. An atom or a molecule in a solid is oscillating, very nearly, in a simple harmonic motion (SHM) about a fixed mean equilibrium position even at zero kelvin temperature. A proton or a neutron in a nucleus is also oscillating in its own rest frame.

2.1 The ELECTRON

An electron is an elementary particle with the smallest non-zero rest mass. It has a negative electric charge, which generates a field in free space, extending to infinity, and is conversely acted on by forces due to the field.

A static electron in free space does not have a uniform motion in a straight line in a given inertial frame of reference, but is not a fixed particle at rest. It is oscillating in a SHM with non-thermal, intrinsic electromagnetic inertia, standing wave, resonance Compton frequency, in its own rest frame.

Assume an isolated electron in free space to be at rest at the origin in a given inertial frame of reference. Let this electron be subject to a tiny force F along the (+) y-axis. A uniformly accelerating electron along the (+) y-axis gives rise to a uniformly changing electric field. This will induce a uniformly changing magnetic field, which will induce a uniformly changing electric field, so as to oppose the initial change in the electric field. This will cause the electron to decelerate and come to rest at some point (+a) on the y-axis.

The decelerating electromagnetic force on the electron will continue to act along the (+) y-axis and cause the electron to accelerate along the (-) y-axis. Since, deceleration along the (+) y-axis is equal to acceleration along the (-) y-axis. The electron will accelerate towards the origin. At the origin the initial force F will now be acting along the (-) y-axis. This force will carry the electron to a point (-a) on the y-axis, where the electron will again come to rest, change direction and accelerate towards the origin. And so on.

A particle at rest at the origin in a given inertial frame of reference, when subject to a force along the x-axis, will move with a uniform motion in a straight line along the x-axis. However, an electron which is oscillating along the y-axis, in a SHM, with its fixed mean equilibrium position at the origin; when subject to a force along the x-axis at the origin, will move along a sine wave path in the xy-plane along the x-axis, even at relativistic velocities. This explains the physical concept of the wave-particle nature of the electron. Also see #10.0 below.

The intrinsic oscillation nature of a static electron is in accordance with the law of conservation of energy and is similar to an ideal simple pendulum oscillating in a SHM in the earth’s gravitational field. The potential field vector direction and the kinetic field vector direction of a SHM oscillating pendulum are orthogonal. The potential field and the kinetic field are in phase quadrature. The potential energy plus kinetic energy is always a constant.

The electric (E) and magnetic (H) fields of a SHM oscillating electron are orthogonal and in phase quadrature. The electric field energy plus magnetic field energy is always a constant. This SHM, non-thermal, standing wave, intrinsic electromagnetic inertia generating resonance is at the electron Compton frequency, as per de Broglie. See #3.0 below. An analysis of the oscillating electron is also given by Petr Beckmann [1].

The earth's conservative gravitational field is external to the simple pendulum. But, an electron oscillates in a SHM, in its own electromagnetic inertia field. This is non-thermal zero point vibration at absolute zero. The zero point energy is the lowest possible vibration energy; this is at zero kelvin and is non-zero. By wave mechanics, the zero-point energy for a linear simple harmonic oscillator of frequency f is ½ hf, where h is the Plank constant.

As per Galileo's law of inertia or Newton's first law of motion, a physical body is either at rest or will continue to move with a uniform motion in a straight line with a constant velocity. An ideal simple pendulum is either at rest or will continue to oscillate in a SHM. A static electron in free space is always oscillating in a SHM in its own rest frame.

This non-thermal, intrinsic electromagnetic inertia, resonance Compton frequency, standing wave, SHM oscillations is as fundamental as (i) the uniform motion in a straight line, law of linear inertia or the conservation of linear momentum and, (ii) the law of rotational inertia or the conservation of angular momentum.

An ideal simple pendulum will oscillate along a linear path or, along an elliptical or a circular path (conical pendulum). Similarly, an electron can oscillate along a linear path or, along an elliptical or a circular (clockwise or anti-clockwise) path, which contributes to the electron's intrinsic magnetic moment (up or down). This also explains Schrödinger zitterbewegung (zbw) theory. See #11.0 below.

2.2 The PROTON

A proton is a quantum particle with a positive electric charge equal in magnitude to the negative electric charge of an electron.

An isolated static proton in free space exhibits non-thermal, intrinsic electromagnetic inertia, standing wave, SHM oscillations (linear, elliptical or circular) in its own rest frame. This is similar to that of an electron. See #2.1 above. The electric (E) and magnetic (H) fields of a SHM oscillating proton are orthogonal and in phase quadrature. The electric field energy plus magnetic field energy is always a constant. The SHM electromagnetic inertia generating resonance is at the proton Compton frequency.

The mass of a proton is about 1836 times that of an electron. So, the amplitude of a proton oscillation is about 1836 times less than that of an electron. The Compton wavelength is characteristic of the mass of a particle and for a proton is about 1/1836 times that of an electron.

2.3 The NEUTRON

A neutron is a quantum particle with a mass about equal to that of a proton. It has zero electric charge but has an intrinsic magnetic moment. It is like a quantum dipole magnet with a N-pole and a S-pole.

Assume an isolated neutron in free space to be at rest at the origin in a given inertial frame of reference, with its magnetic NS-axis parallel to the y-axis. Let this neutron be subject to a tiny force F along the (+) y-axis. A uniformly accelerating neutron along the (+) y-axis gives rise to a uniformly changing magnetic field. This will induce a uniformly changing electric field, which will induce a uniformly changing magnetic field, so as to oppose the initial change in the magnetic field. This will cause the neutron to decelerate and come to rest at some point (+b) on the y-axis.

The decelerating electromagnetic force on the neutron will continue to act along the (+) y-axis and cause the neutron to

accelerate along the (-) y-axis. Since, deceleration along the (+) y-axis is equal to acceleration along the (-) y-axis. The neutron will accelerate towards the origin. At the origin the initial force F will now be acting along the (-) y-axis. This force will carry the neutron to a point (-b) on the y-axis, where the neutron will again come to rest, change direction and accelerate towards the origin. And so on.

An isolated static neutron in free space exhibits non-thermal, intrinsic electromagnetic inertia, standing wave, SHM oscillations (linear, elliptical or circular) in its own rest frame. This is similar to that of an electron or a proton. See #2.1 and #2.2 above. The magnetic (H) and electric (E) fields of a SHM oscillating neutron are orthogonal and in phase quadrature. The magnetic field energy plus electric field energy is always a constant. The SHM electromagnetic inertia generating resonance is at the neutron Compton frequency.

2.4 ATOMS & MOLECULES

Atoms and molecules are quantum particles with a zero net electric charge. Polar molecules have an electric moment. Atoms and molecules with unpaired electrons are paramagnetic and possess a magnetic moment. The atomic nucleus has an electric and a magnetic moment of its own. Nuclear magnetic moment (nuclear magneton) is about 1836 times weaker than atomic magnetic moments, orbital or intrinsic, (Bohr magneton).

An isolated static atom or a molecule in free space exhibits non-thermal, intrinsic electromagnetic inertia, standing wave, SHM oscillations (linear, elliptical or circular) in its own rest frame. This is similar to that of an electron, proton or a neutron. See #2.1, #2.2 and #2.3 above. The magnetic (H) and electric (E) fields of a SHM oscillating atom or a molecule are orthogonal and in phase quadrature. The magnetic field energy plus electric field energy is always a constant. The SHM electromagnetic inertia generating resonance is at the atom or the molecule Compton frequency.

The SHM vibration of atoms or molecules in a solid at zero kelvin temperature is due to their own electromagnetic inertia field, which is the cause of the non-thermal, zero point vibration energy at absolute zero.

2.5 The PHOTON

A photon is a quantum of electromagnetic radiation and an elementary particle with a zero electric charge. It either has a zero rest mass or a finite non-zero rest mass in the range, 10^-68 to 10^-45 kg [6]. In free space, photons always travel in straight lines with the fundamental speed of light {c=3x10^8 m/s, a universal constant of relativity}, at all times, in all directions, in all inertial frames, independent of the relative motion of sources and detectors.

A photon has a real longitudinal magnetic field B(3) whose quantum equivalent is the Evans photomagneton, which has all the known properties of magnetic flux density (Tesla = Weber per square meter). Circularly or elliptically polarized light acts as a magnet upon interaction with matter. This is the 'inverse Faraday effect' (IFE). Unpolarized light does not exhibit IFE. This magnetization is proportional to the light intensity [6], and the light intensity is proportional to the photon flux density, as per Einstein's correlation of the number of photons in a light beam with its intensity. A circularly polarized laser beam of intensity 10^4 W m^-2 (1 W cm^-2), the magnitude of the longitudinal magnetic field is about 10^-5 Tesla or about 0.1 G, roughly a tenth of the earth's magnetic field [6].

The real longitudinal magnetic field B(3) of the photon was discovered in 1992 by Professor Myron Wyn Evans* [4,5,6]. A landmark historical event, with far reaching insights, in our understanding of the physical nature of the enigmatic photon. The B(3) field gave rise to the theory of O(3) electrodynamics, which has been the key in helping Evans complete Einstein's work on the unified field theory. O(3) electrodynamics is a theory of General Relativity and is a consequence of the fact that 3-D space has an O(3) symmetry. O(3) symmetry implies invariance under rotations and reflections.

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The longitudinal electric field of a photon is imaginary (complex numbers). The transverse orthogonal magnetic (H) and electric (E) fields of a photon are real. The photon is its own antiphoton since it has no charge, baryon number, lepton number or strangeness. The direction of the real longitudinal magnetic field is opposite for photon and antiphoton [6]. The enigmatic photon, a quantum of electromagnetic radiation, is a magnetic dipole; it is a quantum magnet. This assumption by Rajpal will be clear as we proceed. An antiphoton is a photon with its magnetic polarity reversed, that is, from NS to SN or vice versa.

3.0 RESONANCE COMPTON FREQUENCY

A quantum particle either has an intrinsic electric charge and /or an intrinsic magnetic nature. An electron has a negative electric charge and an intrinsic magnetic moment. A proton has a positive electric charge and an intrinsic magnetic moment. A neutron has no electric charge but has an intrinsic magnetic moment. A photon is an elementary magnet. See #2.5 above. Atoms and molecules exhibit an electric and a magnetic moment.

This electromagnetic nature of a quantum particle explains why a quantum particle is never at rest but, exhibits intrinsic electromagnetic inertia, standing wave, resonance Compton frequency, SHM oscillations (linear, elliptical or circular) in its own rest frame. See #2.0 above. This is self interaction of a quantum particle with its own electromagnetic field which extends to infinity. A quantum particle cannot be separated from its intrinsic electromagnetic field.

This also explains the zero point energy (ZPE) or ZP oscillations of a quantum particle. ZPE is non-thermal, lowest possible energy, which is at zero kelvin and is non-zero. The ZP oscillations (linear, elliptical or circular) cannot be separated from a quantum particle. Absolute zero temperature is a state at which no further energy can be removed from a quantum particle. Only thermal energy can be removed from a particle, whereas ZPE is non-thermal and electromagnetic in nature.

Extracting ZPE from a quantum particle will transform the very nature of the particle.

For an electron with rest mass energy E, rest mass m, and frequency f, we have:

$E = mc^2$ and $E = hf$

Where, c is the speed of light and h is the Plank constant.

So, $mc^2 = hf$ and $f = (mc^2)/h$

According to de Broglie, f is the electron Compton frequency and is a fundamental intrinsic oscillation of the electron. An electron is always oscillating at the Compton frequency in its own rest frame. This inertia generating resonance is only at the electron Compton frequency.

Also h/mc is the electron Compton wavelength. An electron cannot be confined to a region smaller than its Compton wavelength. For an electron oscillating in a linear SHM, the Compton wavelength is twice the amplitude. For an electron oscillating in a circular SHM, the Compton wavelength is equal to the diameter.

The electron rest mass is equivalent to the energy of a photon of wavelength equal to the electron Compton wavelength. Similarly, the rest mass of an elementary particle is equivalent to the energy of a photon with a wavelength equal to the Compton wavelength of that particle.

The electron Compton wavelength is 1/137 times the Bohr radius and is 137 times the classical electron radius. 1/137 is the dimensionless fine-structure constant alpha. Also the strong interaction is 137 times the electromagnetic interaction.

4.0 PHOTON DOWN-CONVERSION

Down-conversion is a process wherein, under certain circumstances, a pulsed pump laser beam photon incident on a special non-linear optical crystal will output two correlated daughter photons. The polarization of each output photon is orthogonal to that of the other.

The two, quantum entangled, output photons can have equal or unequal frequencies. For equal frequencies, the twin photons will have twice the wavelength and half the frequency (or energy) of the primary or parent photon.

Parametric down-conversion (PDC) is a non-linear process wherein, a light ray impinging on a non-linear crystal creates two new light rays, usually called signal and idler, obeying energy and momentum conservation. The signal and idler photons are perfectly correlated in energy (frequency), emission times, polarization and angular momentum (spin and orbital). The two photons (idler and signal) are always produced together. A circularly polarized photon carries a spin angular momentum. Polarization (clockwise or anticlockwise) enables only two photon spin states. Also see #8.0 below.

A photon down-converter is a device that splits a high-energy photon into two low-energy photons. When a photon reaches the down-converter, it excites an electron into a higher energy level. But the electron returns to its ground state via an intermediate energy level, and emits a lower energy photon at each stage. Three-photon down-conversion is also observed.

A down-converter is a special non-linear crystal that splits a single photon into two. A laser ray (pump-photons) passing a down-converter is split into a signal ray and an idler ray corresponding to signal-photons and idler-photons. Energy conservation requires that the pump-photon frequency be equal to the signal-photon frequency plus the idler-photon frequency. The signal frequency and idler frequency can be equal or unequal and depend on the angle the pump wave vector makes with respect to the crystal axis.

Photon up-conversion is a process which occurs when a material is photo-excited by two or three low-energy photons resulting in the emission of a higher energy photon. A converter seeks to either produce one high-energy photon from two or three low-energy photons (up-conversion) or, two or three low-energy photons from one high-energy photon (down-conversion).

Semiconductors with radiatively efficient impurities can potentially act as up or down-converters. A crystal of beta barium borate (BBO)

can split an ultraviolet photon of wavelength 390 nm into two infrared photons of wavelength 780nm. The two down-conversion photons have orthogonal polarization.

In the Sun a gamma ray photon in the radiation zone, on its way to the photosphere, transforms into a hundred thousand visible light photons during its journey through the turbulent conduction zone. See #26.0 below. A high frequency photon is a Bose condensate (BC) of a number of low frequency photons. See #13.0 below.

The Evans photomagneton has all the known properties of magnetic flux density (Tesla = Weber per square meter). See #2.5 above. If a low frequency photon is an atom of magnetism then a high frequency photon is a molecule of magnetism. The more the number of magnetic atoms, the heavier is the resulting magnetic molecule. See #5.0 below. The photon wavelength of the heavier molecule is in conformity with de Broglie equation. See #13.0 below.

5.0 PHOTON MASS

The photon has several properties that distinguish it from all other subatomic particles. It is the only elementary particle wherein a high-energy photon can transform /split into two or more low-energy photons. This is observed in photon down-conversion. See #4.0 above. This transformation conforms to the laws of conservation of momentum and of energy. The Evans photomagneton or the photons longitudinal magnetic field for a photon also has to be conserved.

If, for example, a visible-light photon (wavelength 405 nm) splits up into two infrared photons (wavelength 810 nm), then, the photomagneton value of the visible light photon has to be equal to the sum of the photomagneton values of the two infrared photons. This implies that the photomagneton value is inversely proportional to the photon wavelength or directly proportional to the photon frequency.

An electron is an electromagnetic object. It seems that a part or perhaps even all the mass of an electron may be electromagnetic in origin. A photon is a completely electromagnetic object. Its mass is probably entirely electromagnetic in nature. It perhaps has no “ordinary” mass at all. An electron is indivisible but a photon can split and also join with another photon. See #4.0 above. If, the Lorentz

electron is an “atom of electricity” then, the Evans photon is a “molecule of magnetism”.

Also, for a photon with energy E, mass m, and frequency f, we have:

E=mc^2 and E=hf so, mc^2=hf

Since, the Plank constant h and the photon speed c are universal constants, so, the photon mass is directly proportional to the photon frequency. As seen above, the photomagneton value is also directly proportional to the photon frequency. So, the photomagneton value corresponds to the electromagnetic mass of the photon.

Einstein understood that photons are a mass-energy transfer mechanism. The emission (or absorption) of a photon by an electron, results in a decrease (or increase) in the mass-energy of the electron.

6.0 PAIR PRODUCTION

A photon with sufficient energy can be transformed into a real electron-positron pair. The mass-energy is conserved as per Einstein’s law of equivalence of mass and energy. The photon’s magnetic charge is conserved and transforms into the electric charge of the electron and the positron. This electric charge results from the rotational (curl) SHM oscillations of the quantum magnet, the photon. It is not something added on to a particle. See #14.0 below. Just as, the electron’s intrinsic magnetic moment, result from the rotational SHM oscillations of the electron. See #2.1 above.

Pair production is direct conversion of radiant energy to matter plus anti-matter. The photon may well be the common denominator of all energy, matter and anti-matter in the universe. All energy is electromagnetic in nature and, all mass is probably electromagnetic in origin. Also see #5.0 above and #23.0 below.

7.0 STRING THEORY

A theory of elementary particles and fundamental forces of nature. The theory replaces point like elementary particles by one-dimension strings. Open strings have free ends and closed strings form loops. Elementary particles are strings vibrating in different modes. The emission of a photon by an electron is the splitting of a string into two

strings. The absorption of a photon by an electron is the joining of two strings into one. Interactions in string theory occur by joining and splitting of strings. In pair production, a photon-string splits up into two strings, with the vibration pattern of an electron and a positron.

The first suggestion of string theory was made by P A M Dirac in 1950. Yoichiro Nambu proposed his string theory in 1970 [9]. Nambu's strings are massless, vibrating, oscillating, rotating, one-dimension objects, which are free to split or join, and move at the speed of light. The strings create their own dynamic spacetime rather than simply moving in some background space. Superstring theories involve the idea of higher dimensional spaces; ten dimensions for fermions and 26 dimensions for bosons.

String theory is a mathematical model in search of a physical model. A simple physical model by Rajpal of the string theory is that, "a string is a standing wave photon moving (vibrating, oscillating, rotating, spinning, twisting, turning) in a SHM". The different SHM vibration, rotation and oscillation patterns (linear, elliptical or circular) of the quantum magnet, the photon, create their own dynamic electromagnetic spacetime. The photon motion, probably correspond to and create the different masses and force charges (electromagnetic, strong and weak nuclear interactions) of the various elementary particles. Also see #14.0 below.

This physical model of the string theory explains the original string theory idea that an elementary particle is an (electromagnetic) standing wave. It also interprets: Edward Witten's [2] view that "an electron is a little vibrating string"; Michael Green's [2] comments that "the strings vibrate not only in space but also in time"; "the spacetime, in which the string is moving, is itself altered by strings"; and the additional dimensions are "not really dimensions at all" [9]. The additional dimensions in string theory do not relate to 4-D spacetime but to force charges; just as in the 5-D Kaluza-Klein theory the fifth dimension refers to Maxwell's electromagnetic field.

We have seen in #2.0 above that an electron, proton or a neutron exhibits electromagnetic inertia, resonance Compton frequency, standing wave, SHM oscillations in its own rest frame. This can be

linear, elliptical or circular. Linear oscillations correspond to open strings and, the elliptical and circular to closed strings.

As stated in #19.0 below, unpolarized light has a predominantly elliptical character. Probably, for all quantum particles, the elliptical SHM oscillation nature dominates over linear SHM oscillations. This explains John Schwarz's [2] notion as to why "closed string theories look the most promising", and Edward Witten's [2] observation that, "most string theories have only closed strings". The constantly changing character of unpolarized light mentioned in #19.0 below, means that a string (that is a photon moving in one-dimension) is itself moving and tracing out a two-dimension surface or a membrane.

8.0 INTRINSIC SPIN & ORBITAL ANGULAR MOMENTUM

Quantum particles carry energy and angular momentum. Angular momentum has two components: spin angular momentum (SAM) and orbital angular momentum (OAM). The SAM of the earth gives us day and night. The OAM of the earth gives us the seasons, as the earth moves around the sun. Spin is a fundamental property of subatomic particles. It is a quantum mechanical property and is present in both moving and particles at rest. OAM results from the motion of a particle around some object, like an electron around a nucleus.

Intrinsic spin does not imply that a quantum particle, like an electron, is spinning like a top about its axis. It corresponds to the circular or elliptical oscillations of a quantum particle. An analogue in classical mechanics is the conical pendulum. See #2.1 above. Also see #11.0 below. In subatomic particles, the intrinsic spin angular momentum is quantized. It always comes in fixed discrete units that are integer multiples of ½(h-bar). For ease of expression, a particle with spin ½(h-bar) is referred to as having 'spin ½'. Also, the electric charge is quantized and comes in simple multiples of the fundamental unit of electron charge.

The intrinsic spin of an electron and a photon has only two quantum mechanical eigenstates. For an electron this refers to spin-up or spin-down, that is, clockwise or anticlockwise oscillations. See #2.1 above. For a photon it corresponds to circular polarization (clockwise or anticlockwise) and the photon's magnetic polarity, that is, NS or SN. The longitudinal B(3) field is directly proportional to the spin angular

momentum [6]. Photons have a spin angular momentum quantum number of 1. For the electron the SAM is ½. Photons carry both spin and orbital angular momentum (OAM). Photon OAM has an infinite number of quantum mechanical eigenstates.

A photon is a boson with an intrinsic spin of 1. A photon (NS or SN) if rotated in space through 360 degrees will return to its original configuration. A proton or a neutron is a fermion with an intrinsic spin of ½, and has to be rotated through 720 degrees before it returns to its starting configuration. A proton or a neutron probably oscillates, tracing a figure of 8 as in a Lissajous' figure in a cathode ray oscilloscope. This corresponds to a rotation of 720 degrees and also explains the shape of the Calabi-Yau space concept in string theory [7].

9.0 De BROGLIE WAVELENGTH

French physicist Louis de Broglie in 1923 predicted that quantum particles, like the electron, might exhibit wave properties like the photon. This was confirmed in the Davisson-Germer experiment in 1927.

The de Broglie wavelength of a particle (or a physical body) of mass (m), moving with a velocity (v), is equal to (h/mv), where (h) is the Plank constant. The de Broglie wavelength of a tiny dust particle weighing one microgram and moving with a velocity of one millimeter per second is 6.6x10^-12 angstrom. For heavier particles moving at higher velocities, the wavelength decreases. So, macro particles do not exhibit de Broglie or matter waves characteristics and appear to be moving in a straight line. But, in reality nothing moves in a straight line. See #10.0 below. The de Broglie wavelength of the planet earth moving in an elliptical orbit around the sun can be calculated, and is 3.7x10^-63 m; just as we can do so for an electron in a one-proton hydrogen atom. A particle at rest does not have a de Broglie wavelength.

10.0 WAVE MECHANICS

A particle at rest at the origin in a given inertial frame of reference, when subject to a force along the x-axis, will move with a uniform motion in a straight line along the x-axis. However, a quantum particle, which is oscillating along the y-axis, in a SHM, with its fixed

mean equilibrium position at the origin; when subject to a force along the x-axis at the origin, will move along a sine wave path in the xy-plane along the x-axis, even at relativistic velocities. This explains the physical concept of wave mechanics. Matrix mechanics represents a tabulated form of wave mechanics.

A static electron oscillates (linear, elliptical or circular) with resonance Compton frequency in its own rest frame. Twice the amplitude of this linear resonance oscillation is equal to the Compton wavelength. An electron moving with a velocity (v) will have a de Broglie wavelength equal to (h/mv) where, (h) is the Plank constant and (m) is the electron mass.

The amplitude, time period and frequency of a uniformly moving oscillating electron are the same as that of a stationary oscillating electron. The electron linear velocity depends on the force that is applied to the stationary oscillating electron. The de Broglie wavelength is equal to the electron velocity divided by the electron Compton frequency. A static electron exhibits a standing wave at the resonance Compton frequency in the electron rest frame. A moving electron has a traveling wave with a de Broglie wavelength. The amplitude of both the standing wave and the traveling wave is equal to one-half the Compton wavelength.

The Compton wavelength (h/mc) is the shortest possible de Broglie wavelength (h/mv) as the particle velocity (v) approaches the speed of light (c). Since, a photon always moves with the speed of light, so, for a photon, twice the amplitude (Compton wavelength) is always equal to the photon wavelength (de Broglie wavelength). The light intensity does not depend on the square of the amplitude but is proportional to the photon flux density, as per Einstein’s correlation of the number of photons in a light beam with its intensity.

An electron is a particle but its motion is described by wavelike principles. Photons propagate through space in a wavelike fashion but display particle like behavior during emission and absorption. An electron or a photon does not move in a straight line but along a sine wave path.

The wavelength (or twice the amplitude) of gamma rays and x-rays photons is in the range, 10^-13 to 10^-9 meter, and so they behave more like particles moving in a straight line. For microwaves and radio waves photons, the wavelength (or twice the amplitude) is in the range, 10^-3 to 10^5 meter, and so they display more of wave like attributes. The wavelength (or twice the amplitude) of visible light photons is in the range, 10^-7 to 10^-6 meter, and they exhibit dual wave-particle nature.

For 3 cm wavelength microwaves (linearly polarized), a wire-grid with a spacing of about 7-8 mm, roughly one-quarter of a wavelength; the grid is completely transparent only when the wires are parallel to the transverse magnetic (H) field vector direction of the microwaves [10]. This shows that a photon oscillates in the transverse magnetic (H) field vector direction unlike the electron, which oscillates in the electric (E) field vector direction. Similarly, a proton oscillates in the electric (E) field vector direction and a neutron oscillates in the magnetic (H) field vector direction.

Similar to the electron, proton or the neutron; the transverse magnetic (H) and electric (E) fields of a photon are orthogonal and in phase quadrature. The magnetic field energy plus electric field energy is always a constant. This contributes to the electromagnetic inertia, SHM oscillations (linear, elliptical or circular) of the photon; and gives a physical explanation of why photon speed is independent of the relative motion of sources and detectors, at all times, in all directions, in all inertial frames.

The mathematical symmetry of the free space Maxwell's equations, imply that the magnitudes of the transverse orthogonal magnetic (H) and electric (E) fields are physically equivalent. However, their numerical values in SI units are not equal since, the permeability and permittivity of free space have unequal numerical values in SI units.

11.0 ZITTERBEWEGUNG (ZBW)

A theory proposed by Schrödinger (1930), zitterbewegung (zbw) is a German word for jitter motion. Zitterbewegung is a local circulatory motion of the electron presumed to be the basis of the intrinsic spin and magnetic moment. Zbw provides a physical interpretation for the complex phase factor in the Dirac wave function. Zbw is a real

physical phenomenon and corresponds to a particle going along a cylindrical helix, at the speed of light, in real space with a diameter equal to Compton wavelength. The zbw frequency is the electron resonance Compton frequency. David Hestenes [8] has written extensively on the zbw theory and his articles are available on the web.

12.0 ATOMIC ORBITAL

Since an electron does not move in a straight line but along a sine wave path, so, electrons in atomic orbits do not move in a linear circular path but along a sine wave, circular path [1].

If, the electron orbit circumference is an integral multiple of the electron de Broglie wavelength; the electron which is moving in a sine wave circular path, will repeat the same sine wave path in each successive orbit. The sine wave paths in consecutive orbits will exactly overlap. The electron wave reconnects with itself and is in phase with itself. The electric (E) and magnetic (H) fields oscillate in space and time but do not travel in space and time. This is a stable standing wave electron orbit. The orthogonal E and H fields are in phase quadrature.

If, the electron orbit circumference is not an integral multiple of the electron de Broglie wavelength, the sine wave paths in successive orbits do not overlap. The electron wave does not reconnect with itself and is not in phase with itself. The electric (E) and magnetic (H) fields travel in space and time along the electron orbit circumference. It is not a standing wave and so is an unstable electron orbit.

13.0 BOSE-EINSTEIN CONDENSATION (BEC) OF ATOMS AND BOSE CONDENSATION (BC) OF PHOTONS

Indian physicist Satyendra Nath Bose re-derived the black-body radiation spectrum by treating the radiation field as a gas of identical particles of photons. Bose statistics introduced in 1920 show how a collection of photons are distributed among various energy states at a given temperature.

Einstein in 1924 generalized this into Bose-Einstein statistics for an ideal gas of boson atoms or molecules and predicted Bose-Einstein condensation (BEC) of boson atoms or molecules in the ground state

at very low temperatures in the nanokelvin range. A BEC is a state of matter formed when a liquid or gas of bosons is cooled below a certain critical temperature. The first BEC with super cooled rubidium atoms was created in 1995.

Solid, liquid, gas and plasma are the four physical states of matter. BEC is the fifth state of matter beyond solids with a density more than the solid state. At room temperature the de Broglie wavelengths of the atoms or molecules in a gas are 10,000 times smaller than the average spacing between the gas atoms or molecules. BEC is a gaseous superfluid phase formed by atoms cooled to a point where the thermal de Broglie wavelength is comparable to the mean inter-atomic separation.

At very low temperatures, in the nanokelvin range, the de Broglie wavelength of the atoms or molecules can be comparable to the mean distance between the atoms or molecules. The wave of one atom (or molecule) overlap with that of the neighboring atom (or molecule) causing them to loose their separate identity. The individual waves merge together, lock into, and end up in the same wave function, resulting in a single coherent quantum state.

BEC is a new form of matter. In a BEC every atom or molecule must move in the same manner at the same time. Coherence is the defining criterion for the BEC phase. BEC is a coherent cloud of atoms, all in the same quantum mechanical state. In a BEC the atoms or molecules are all perfectly in phase, in the same energy state, as compared to the randomly moving atoms or molecules in a gas.

An essential property of BEC is macroscopic phase coherence. The wave function, of all the atoms in the condensate, consists of a superposition of identical wave functions. The wave function, of the macroscopic quantum state, remains coherent for a number of bosons. BEC is a blend of atoms or molecules acting in unison with their motion identical to one another.

The individual atoms or molecules overlap each other and coalesce into a super atom or a super molecule, described by one single wave function exactly as in a single atom or a molecule. A super atom or a molecule is a collection of coherent atoms (or molecules) merged into

a single dense entity, and behaves like an individual atom or a molecule. BEC of millions of atoms, a few millimeters across with a density of 10^14 atoms/cc have been created, and behave as one giant coherent atom.

Creating a BEC is simple in principle. Cool a gas until the thermal de Broglie wavelength is the same as the distance between the atoms. A BEC results when an atomic vapor of bosons is cold and dense enough, so that the inter-atomic spacing approaches the thermal de Broglie wavelength. Laser trapping and cooling can slow atoms to very small velocity spreads, so that their de Broglie wavelength corresponds to the average inter-particle separation.

A Bose condensate (BC) of photons is different from a Bose-Einstein condensate (BEC) of a gas of bosons. A high frequency photon is a Bose condensate (BC) of a number of low frequency photons. Jacobson et al [15] had in 1995 shown theoretically that the de Broglie wavelength for an ensemble consisting of N entangled photons, each with a wavelength L, would be L/N. A collection of N entangled photons with frequency f behave as a single entity with frequency Nf.

This proposition was verified experimentally in 2002 for the case of two entangled photons by Edamatsu et al [16]. The two photons behave as if they acted as a single entity with a wavelength half that for either photon alone.

14.0 ELECTRON PHYSICAL MODEL

Mathematics is the language of physics. A problem in physics can be resolved by different mathematical models. But, there can be only one physical model for explaining the problem. All mathematical models of the electron must conform to the same physical model.

The ring model of the electron was first suggested by Alfred L Parson in 1915. Bergman and Wesley [17] in 1990 developed the spinning ring model of the electron wherein, the electric charge on the ring surface rotates at the speed of light. The size of the electron equals the rationalized Compton wavelength, and the frequency of rotation equals the Compton frequency.

A suggested physical model of the electron by Rajpal is: A static electron is a standing wave photon (with an electron-resonance-Compton-frequency) moving at the speed of light in a circular orbit, with a diameter equal to the electron-resonance-Compton-wavelength. The photomagneton value of the photon gives rise to the electron charge at the center of the circle as per the Maxwell equations.

An electron moving with a velocity v is a photon (with an electron-resonance-Compton-frequency) moving at the speed of light along a cylindrical helix, with a diameter equal to the electron-resonance-Compton-wavelength; and a pitch equal to the de Broglie wavelength, or the velocity v divided by the electron-resonance-Compton-frequency. Also see #11.0 above.

Just as an electron moving in a circular orbit in an atom results in a magnetic moment. Similarly, a magnetic dipole photon moving in a circle results in an electric charge at the center of the circle. Since, the electron charge value is precisely known, so, we can calculate the theoretical photomagneton value for an electron-resonance-Compton-frequency photon. The photomagneton value at any other photon frequency can be obtained as explained in #5.0 above.

This ring model of the electron, viewed together with the Bose condensation (BC) concept of photons, explains the emission or absorption of a photon by an orbiting electron in an atom, when changing orbits. The electron mass-energy changes due to loss or gain of a photon. This results in a change in the electron de Broglie wavelength and enables the electron to continue to be a stable standing wave in its new orbit. See #12.0 above.

This electron physical model seeks to unify three different schools of thoughts in physics; the Evans photomagneton concept with the zitterbewegung and the string theory. See #11.0 and #7.0 above.

Einstein’s relativity is a sound mathematical model based on a simple physical model. Epicycles were a complicated mathematical model based on a complex physical model. The mathematical model of the Evans unified field theory is based on the physical model or the geometrical concept of the tetrad. A tetrad is a (4x4) matrix and is the basic element of 4-D spacetime. Also see #23.0 below.

15.0 DIFFRACTION

The diffraction behavior of photons, electrons, protons, neutrons, atoms and molecules is elastic scattering of quantum particles moving along a sine wave path and not in a straight line. This sine wave path of quantum particle travel makes it easy to visualize the following:

15.1 Diffraction or the elastic scattering of photons, electrons or neutrons by the periodic structure of the atoms in a crystal.

15.2 The angular spread of the diffraction pattern is inversely proportional to the slit width.

15.3 The diffraction width is directly proportional to the amplitude or wavelength.

The pinhole diffraction of a ray of linearly polarized photons from a wavelength aperture will be along the transverse magnetic field vector direction and have an angular spread of 90 degrees [12]. The ray must be at the center of the aperture. This should be easy to observe with millimeter or centimeter wavelength photons.

16.0 INTERFERENCE

First a conceptual picture of what happens to photons traveling through a single slit is given, followed by an explanation of two-slit interference.

16.1 SINGLE SLIT

Imagine seven horizontal parallel rays of light traveling in the x-axis direction, in a horizontal xz-plane; through a vertical slit (y-axis) with a slit width of 7-wavelengths (from z=-3.5 to z=+3.5).

Let the rays be numbered from #1 to #7 with ray #4 in the middle (x-axis).

Rays #3, #4 & #5 (z = -1, 0 & +1) will travel straight through the slit onto the screen.

Rays #1 & #7 (z = -3 & +3), being close to the slit walls, will experience diffraction due to elastic scattering since; the photons are traveling along a sine wave path and not in a straight line.

Photons traveling along rays #2 & #6 (z = -2 & +2) will experience some diffraction due to elastic scattering of photons in the neighboring rays #1 & #7 (z = -3 & +3).

16.2 TWO SLIT INTERFERENCE

Figure 1 below, represents eight photons of unpolarized light traveling along a horizontal ray in the x-axis direction. Neighboring photons have opposite magnetic polarity; so, unpolarized light does not exhibit magnetism on interaction with matter. Also, the polarization of neighboring photons is orthogonal. In an unpolarized ray, any two neighboring photons are correlated and form a quantum entangled pair.

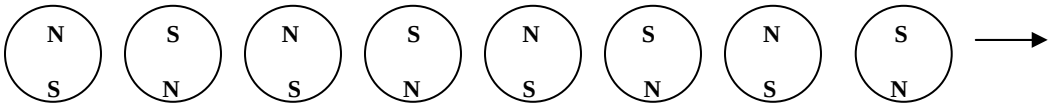

Figure 1

Figure 2 on the next page, represents eight vertical parallel (y-axis) coherent rays of unpolarized light traveling in the y-axis direction. Each ray has four photons. In a coherent beam all rays are in phase. Neighboring photons in the horizontal xz-plane, in adjoining rays, the magnetic polarity is such that unlike magnetic poles face each other, and so attract each other. Photons thereby, exhibit a bunching tendency, a property shown by all bosons.

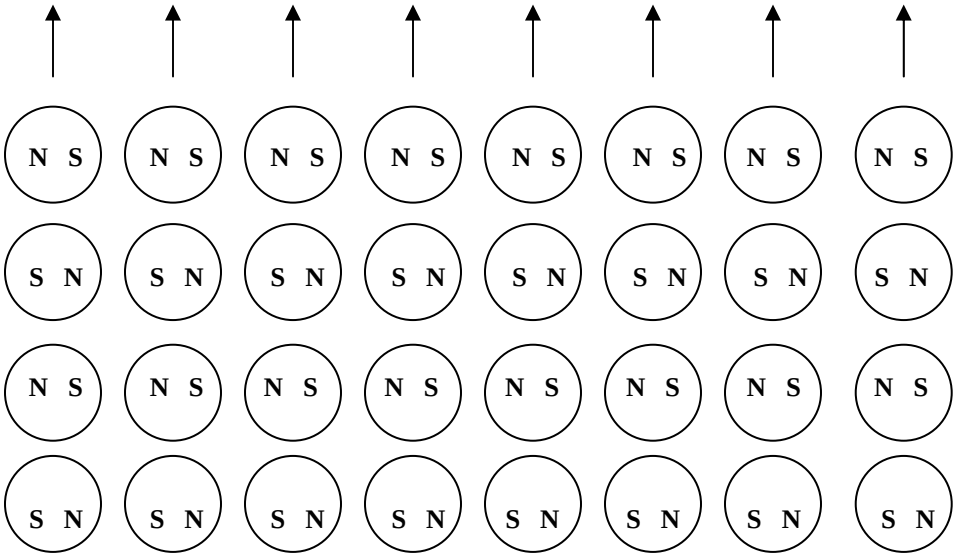

Figure 2

Figure 3 below, represents two vertical rays of unpolarized light traveling in the y-axis direction. Each ray has two photons, as shown. The two adjoining photons are out of phase by 180 degrees. These two adjoining photons will repel each other since, like magnetic poles repel each other.

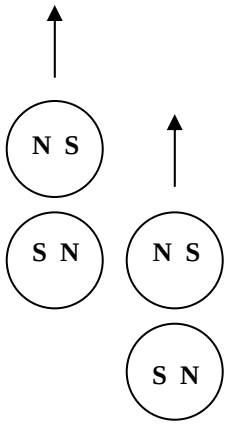

Figure 3

In a double slit interference experiment, photons after being diffracted and traveling from the two slits towards the screen, along two convergent rays of light; if on arrival at a point on the screen, are out of phase by 180 degrees, will repel each other

and get deflected to neighboring areas, thereby creating a dark band between two bright neighboring bands. This explains Thomas Young's interference experiment (1801).

For this photon repulsion to occur, the two photons need not arrive on the screen together, at exactly the same point in time. The time interval will be more for a low-intensity one-photon-at-a-time beam; as compared to a high-intensity many-photons-at-a-time, beam. See #17.0 below.

17.0 HANBURY-BROWN & TWISS (HBT) EXPERIMENT

It is reported that two-slit interference occurs even when the intensity is reduced so much that only one photon or electron traverses the apparatus at a time.

However, Robert Hanbury-Brown and Richard Q. Twiss have observed in their experiment (1956) that photons, in a coherent beam, are not emitted one at a time at equal intervals. Photons or electrons in a coherent beam, travel in bunches or groups and not as separate individual particles at equal intervals. The HBT experiment has been well explained by Akira Tonomura [14].

A low intensity coherent photon beam, corresponding to only "one photon at a time", is basically a slow motion movie version of a high intensity coherent photon beam, corresponding to "many photons at a time". Irrespective of the photon intensity, only coherent radiation creates an interference pattern.

Two interference patterns, formed by a low-intensity beam and a high-intensity beam, will be identical for an equal number of photons. The time taken to form will be different. The interference pattern is unrelated to the beam intensity. It is related to the number of photons striking the screen. The basic requirement for interference is a coherent beam of photons or electrons. Coherence is the defining criterion for interference.

Electrons are fermions and obey the Pauli exclusion principle. Electron pairs have zero spin and behave like bosons. Vacuum or free space temperature is near zero kelvin. So, electrons in free space move in pairs, just as they do in a superconductor at a few degrees

above zero kelvin. This bosonic behavior explains electron interference.

18.0 ELECTRON INTERFERENCE

In an electron-ray neighboring electrons have opposite intrinsic spin (up or down); just as in a light ray neighboring photons have opposite magnetic polarity (NS or SN) as shown in Figure 1 in #16.2 above. In a coherent electron beam neighboring electrons in adjoining rays have opposite intrinsic spin (up or down); just as in a coherent light beam neighboring photons in adjoining rays have opposite magnetic polarity (SN or NS). Electron interference is thus similar to photon interference as explained in #16.2 above.

When we observe, as to which one of the two slits the electron is traveling through, we disturb the coherence in the electron beam and so the interference does not occur. Coherence is a must for interference.

19.0 POLARIZATION

Polarization is of three types: linear, circular and elliptical. Elliptical polarization includes the other two as special cases. Natural or ordinary unpolarized visible light has an appreciable bandwidth (VIBGYOR). It includes all three types of polarizations. The most prominent feature of unpolarized light is its constantly changing, predominantly elliptical, character [13].

19.1 LINEAR POLARIZATION

A ray of unpolarized light, (see Figure 1 in #16.2 above), incident on a crystal of calcite or quartz; adjoining photons with opposite magnetic polarity (and orthogonal polarization) travel along different paths through the crystal, resulting in two equal intensity rays of linearly polarized light with orthogonal polarization. Also see Reference [12].

Similarly, a ray of unpolarized light incident on a reflecting surface, at the Brewster angle; alternate photons of a given magnetic polarity (either NS or SN) are reflected at the surface. The remaining alternate photons (50%) with the opposite magnetic polarity (SN or NS) are transmitted in the case of a glass plate or, are absorbed in the case of a metallic mirror. The

equal intensity reflected ray and transmitted ray are both linearly polarized rays with orthogonal polarization. The reflected ray is polarized in the plane of incidence. Also, at the Brewster angle of incidence, the reflected ray is perpendicular to the refracted ray.

In linear polarization, the transverse magnetic field vector is not confined to a single plane of vibration, but has an angular spread of 90 degrees [12].

19.2 CIRCULAR POLARIZATION

Frenchman Francois Jean Arago experimentally discovered circular polarization in quartz in 1811. In circular polarization the transverse magnetic (H) and electric (E) field vectors rotate rather than oscillate as in linear polarization. In both cases the transverse magnetic (H) and electric (E) fields are orthogonal and in phase quadrature. The magnetic field energy plus electric field energy is always a constant. This contributes to the electromagnetic inertia, SHM oscillations of the photon.

In a ray of circularly polarized light, photons travel along a circular (clockwise or anti-clockwise) helix or spiral path of wavelength diameter, or radius equal to the amplitude. All photons in a ray have their magnetic polarity (NS or SN) at 45 degrees to the centerline of the spiral. The longitudinal vector components (cosine45-degree), of the Evans photomagnetons, add up to give a net resultant longitudinal magnetic field.

This explains the ‘optical Faraday effect’ (OFE) and similar magneto-optical effects. The OFE is the rotation of the plane of polarization of a linearly polarized probe beam by a second, circularly polarized, pump laser. The latter substitutes for the magnetic field of the ordinary Faraday effect. See #20.0 below.

The OFE was reported to be ten times greater in magnitude in circular than in linear polarization [6]. Circularly polarized pumping was an order of magnitude more effective than linearly polarized pumping. In linear polarization, the net real longitudinal magnetic field is zero [5]. So, it should not exhibit any IFE and therefore should not display any OFE. But, the fact

is that it does. This goes to show that linearly (open strings) polarized light is mostly elliptically (closed strings) polarized light with a very high degree of ellipticity. This supports the observed string theory view stated in #7.0 above, that most string theories have only closed loops.

20.0 The FARADAY EFFECT

The Faraday effect or the Faraday magneto-optic rotation is the observed rotation of linearly polarized light passing along a rod of very dense glass, or certain other substances, placed along the axis of a strong magnetic field.

If the rotated beam is reflected back towards the source, the rotation is not reversed on the return trip and thus cancelled out, but occurs again so that the rotation is doubled. This may seem paradoxical because light passing the opposite way in the same field is then being rotated the opposite way. This shows, it is not the material of the glass, but the light ray photon has some directional property across its line of travel [10].

Reflection of a photon involves a 180 degrees change of phase. The NS photon on reflection becomes a SN photon or vice versa and so does not reverse its path after reflection. However, in case of internal reflection no phase change occurs and the photon on reflection will retrace its original path.

21.0 PHOTON'S MOMENTUM

Radiation pressure is exerted by unpolarized or linearly polarized photons in the direction of photon travel. This is due to the photon's linear momentum. In a similar manner a mechanical torque is produced by circularly polarized photons. This was observed in an experiment by R A Beth in 1936 [13]. This is due to the photon's angular momentum. See #19.2 above. Both the linear and angular momentum effects of the photon are mechanical in nature and exhibit the particle like behavior of the photon.

22.0 The EINSTEIN-PODOLSKY-ROSEN (EPR) PAPER

In a thought experiment published in a 1935 paper by Albert Einstein, Boris Podolsky and Nathan Rosen; the authors disagree with the

Heisenberg uncertainty principle and concluded that Quantum Mechanics is not a complete theory of nature.

The experiment seeks to look at both the position and momentum of a quantum particle simultaneously [3]. If a photon source placed at the origin in a given frame of reference emits a pair of photons, simultaneously in the opposite direction, say, along the (+) and the (-) x-axis; then, a measurement of either the momentum or position of one photon reveals the momentum or position of the other.

Polarization has been adopted as a convenient means of studying EPR correlations. Any two photons (or electrons) that originate from a common source will possess a total spin of zero.

In an experiment (1982) by French physicist Alain Aspect, a radioactive calcium atom emits two correlated photons of random polarizations in the opposite directions. The photon polarizations are separately measured many meters apart. The left hand detector records random polarizations, correlated to the right hand detector's measurements [11]. Also see Reference [12].

The magnetic polarity of either photon is opposite to that of the other. If the (+) x-axis photon polarity is NS then, the (-) x-axis photon polarity is SN or vice versa. Either photon will maintain its polarity and polarization independent of the other unless acted upon by an external force to change it.

The two photons created by the same source are correlated and form a quantum entangled pair. As mentioned in #16.2 above, it is interesting to note that in a ray of unpolarized light neighboring photons are correlated and form a quantum entangled pair. They have opposite magnetic polarity and the polarization of neighboring photons is orthogonal.

23.0 SPACETIME, MASS & CHARGE

An event is something that happens at a definite point in space and at a definite time. Aristotle believed in absolute space. Galileo's law of inertia or Newton's first law of motion got rid of the idea of absolute rest. The nonexistence of absolute rest meant that one could not give an event an absolute position in space.

Both Aristotle and Newton believed in absolute time, that is, the time interval between two events is the same for all observers, moving or stationary. Einstein's relativity put an end to the idea of absolute time. Time is not separate and independent of space, but is combined with it to form spacetime. Space and time are relative, not absolute. Only spacetime is observer independent.

In Newton's 3-D space, gravity is a force. In Einstein's four-dimension spacetime, gravity is not a force. It is spacetime curvature or compression. The earth moves in a straight-line path in 4-D spacetime. But, it appears to us to move in an elliptical orbit in 3-D space. This is because the mass of the Sun causes the curvature or bending of spacetime. The Sun is 1/3 million times heavier than the earth and contains more than 99.8 percent of the total mass of the solar system.

In 4-D spacetime a particle or an object at rest in space is moving through time; it is ageing. A particle moving with the speed of light in space is at 'rest' in time. There is no passage of time at light speed. The lifetime of an elementary particle increases with its speed as predicted by Einstein's relativity. Relativistic time dilation is observed for atmospheric muons. A muon is an elementary particle identical to the electron but about 200 times heavier.

3-D space or 4-D spacetime is not an absolute vacuum but full of virtual particles. There can be no spacetime without virtual particles. Free space is filled with pairs of virtual particles and antiparticles. They are created together, move apart, and come back together and annihilate. In free space, pairs of virtual electrons and positrons are continuously forming and rapidly disappearing, in less than 10^-23 second, so, our measuring instruments are unable to record their presence and hence the name virtual particles.

Electrons surround themselves with a cloud of virtual photons, which may surround themselves with virtual pairs (electron-positron). An electron moves about in the center of a cloud of virtual photons and virtual electron-positron pairs. Photons and anti-photons are the same. In free space we have the virtual photon field and the virtual electron-positron field (the Dirac field).

Faraday's lines of force, helps visualize magnetic and electric fields. Einstein's concept of spacetime curvature or compression (dot product) helps explain the nature of gravitation. The concept of spacetime torsion or spin (cross product) helps explain the nature of electromagnetism. Gravitation and electromagnetism are the manifestation of the different geometries (curvature or torsion) of spacetime. Gravitation can give rise to electromagnetism and vice versa. Mass is the source of spacetime curvature or bending. Charge is the source of spacetime torsion or spin.

There are three kinds of pions or pi-mesons: positively charged pi(+), negatively charged pi(-) and electrically neutral pi(0). The masses of pi(+) and pi(-) are equal, and are 273 times the mass of the electron. The mass of pi(0) is 264 times that of the electron. We can interpret this difference of 9-electron mass as due to the electric charge. In a sense this means that mass and charge are closely related. Also, we know that the electrostatic field of a charge and the gravitation field of a mass are both governed by the inverse square law.

The basic element of 4-D spacetime is a tetrad. The tetrad is a (4x4) matrix with 16 independent components. Evans has shown that it can be developed as the sum of an anti-symmetric matrix with six independent components (the electromagnetic field) and a symmetric matrix with ten independent components (the gravitation field). The general tetrad matrix mixes the two fields and shows how one influences the other, for any given experimental situation. Also, the Evans unified field theory shows that wave mechanics is a direct result of the tetrad postulate.

Tetrad field (16 components) = Gravitation field (10 components) + Electromagnetic field (6 components).

24.0 BLACK HOLE MAGNETIC FIELD

Escape speed is the speed that an object must attain in order to escape from the gravitational field of an astronomical body. The square of this escape speed is directly proportional to the mass and inversely proportional to the diameter of the star or planet. For the earth, the escape speed is 11.2 kilometers per second.

A black hole is a region of space or of spacetime within which the gravitational field has become so strong that neither particles nor photons can escape from it. It is a sufficiently massive body for which the escape speed exceeds the speed of light. The internal structure of a black hole is not known but will probably consist of elementary particles, including photons. The size of a non-rotating stationary black hole depends only on its mass. If the Sun collapsed into a non-rotating black hole, its radius would be about 3 kilometers. For the earth it would only measure one centimeter.

The surface of a black hole is called the event horizon and defines the boundary from inside which neither mass nor radiation can escape. Above the event horizon is the photon sphere. The photon sphere radius is about 1.5 times the event horizon radius. In a photon sphere, the photons orbit the black hole in circular orbits. A photon in equilibrium in a photon sphere can neither escape the black hole gravitational field nor is it pulled into the event horizon.

A non-rotating black hole is exactly spherical. This sphere constitutes the boundary of the black hole or the horizon that does not let anything out. The structure of a rotating black hole is different from that of a stationary black hole. A rotating or a Kerr black hole is axially symmetric but not spherically symmetric. In a rotating black hole there is an additional zone called the ergosphere. The ergosphere is a solid ellipsoid, a 3-D oval that floats above the event horizon of the black hole.

All stars are known to rotate. The Kerr black hole rotates because the star from which it was formed was rotating, (conservation of angular momentum). Outside the horizon of a Kerr black hole is the ergosphere within which matter is forced to rotate with the black hole. The ergosphere has an oval shape. It is a 3-D ellipse. The ergosphere is in contact with the poles of the event horizon, and at the equator it has up to twice the diameter of the event horizon. The outer boundary of the ergosphere is called the static limit, so named because once inside this boundary, a particle cannot possibly be static or at rest relative to the distant stars.

At the event horizon the gravitation field tends to infinity. Our measuring rods shrink and tend to zero. Time slows down and almost

stops at the event horizon. It takes an infinite long time for the black hole to diminish below the event horizon. Length contraction is compensated by time dilation. When space distances shrink, time intervals lengthen, but spacetime is invariant. The photons, at or below the event horizon, arrange themselves in a 3-D standing wave lattice, with unlike magnetic poles facing each other and so attracting each other. It can also be a Bose condensate (BC) of photons. See #13.0 above.

A black hole, with a mass a few times that of the sun, would have a temperature of only a hundred nanokelvin. Low temperature means low entropy which implies polarization. The photons in the ergosphere are circularly polarized. The powerful magnetic field of super massive rotating black holes, of a million to billion solar masses, at the center of some galaxies, is also due to the circularly polarized photons in the ergosphere.

25.0 NEUTRON STAR MAGNETIC FIELD

A neutron star consists mainly of neutrons, with a radius of about ten kilometers. The escape speed for a neutron star is one-half the speed of light. A neutron has an intrinsic magnetic moment; it is like a quantum magnet with a N-pole and a S-pole. See #2.3 above.

In a stationary neutron star, the neutrons arrange themselves in a three-dimension lattice with unlike magnetic poles facing each other and so attracting each other. It is a Bose-Einstein condensate (BEC) of neutrons. In a rotating neutron star, the neutrons are probably circularly polarized. This may be the cause of a rotating neutron star's observed magnetic field of a billion to a trillion Gauss.

26.0 SUN'S MAGNETIC FIELD

The structure of the Sun consists of the central Core followed by the Radiation zone and the Convection zone. Next are the Photosphere and the Chromosphere near the surface; and the Corona, the atmosphere of the Sun, above the surface. The core contains about 40 percent of the Sun's mass in 10 percent of the volume. The escape speed for the surface of the Sun is 618 km/sec.

The radiation zone is plasma of ionized hydrogen and helium atoms. It is from about 15 percent to 70 percent of the solar radius. The

radiation zone density is 20 g/cc near the core and drops down to only 0.2 g/cc near the conduction zone. Photons from the core move in a zigzag fashion through the radiation zone towards regions of lower temperature and pressure.

It takes about a million years for a photon generated in the interior core of the Sun to travel through the radiation zone, and thereafter a month or so to travel through the turbulent conduction zone and reach the surface of the Sun. A high frequency (gamma ray) photon in the radiation zone, on its way to the photosphere, transforms into a hundred thousand lower frequency (visible light) photons during its journey through the turbulent conduction zone.

The photosphere, as the name implies, consists of photons of natural visible light, mostly unpolarized. It is sprinkled with small dark cool areas called sunspots, which are regions of strong magnetic field and always appear in pairs on the photosphere. Sunspot temperature is 4000 K compared to 6000 K elsewhere in the photosphere. Sunspot magnetic field is about thousand times stronger than the photosphere average. The two sunspots of a pair have opposite magnetic polarity. Lower sunspot temperature means lower entropy which implies polarization, and so sunspots are areas of circularly polarized photons, which explain their magnetic nature.

27.0 SUMMARY

27.1 Quantum particles exhibit intrinsic electromagnetic inertia, resonance Compton frequency, SHM oscillations (linear, elliptical or circular) and travel along a sine wave path and not in a straight line.

27.2 Zero point energy (ZPE) is non-thermal, intrinsic electromagnetic inertia, resonance Compton frequency, SHM oscillations (linear, elliptical or circular) at zero kelvin.

27.3 A photon is a magnetic dipole. It is an elementary magnet. Evans discovery of the photon’s longitudinal magnetic field in 1992 is as significant, as Einstein’s discovery of relativity. It helps in giving a physical interpretation of the string theory, wave mechanics, two-slit interference and the Faraday effect.

27.4 A string is a standing wave photon moving (vibrating, oscillating, rotating, spinning, twisting, turning) in a SHM. The photon motion, correspond to and create the different masses and force charges of the various elementary particles.

27.5 An electron is a standing wave photon (with an electron-resonance-Compton-frequency) moving in a circle with a diameter equal to the Compton wavelength of the electron.

27.6 The magnetic field of a black hole and the Sun is due to circularly polarized photons.

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